Cardiac Operations with Extracorporeal Circulation

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• In a series of 50 patients for whom a heart-lung machine was used for periods as long as 70 minutes during operations to correct structural defects of the heart, there were no deaths attributable to the machine. Seven patients died. Two of them had high pressure ventricular septal defects with bidirectional shunts; a third patient with the same lesion recovered after repair. One patient died of cardiac tamponade when a large blood clot formed about the entire heart in a loosely closed pericardial sac. Others died of various causes. The development of subacute bacterial endocarditis in one patient led to a change in sterilization of apparatus.

THE FOLLOWING REPORT is on the first fifty consecutive cases in which the Kay-Anderson heart-lung machine and the autoclavable stationary screen oxygenator* were used during operations for correction of ventricular septal defect, tetralogy of Fallot and other congenital and acquired lesions. This apparatus is capable of oxygenating and pumping 5 liters of blood per minute. The first patient on whom the autoclavable stationary screen oxygenator was used was operated upon December 12, 1957.

The technique used for all these patients was as follows:

Anesthesia was shallow and was so managed that the patient was awake at the end of the procedure. Wherever feasible hypnosis was used for induction and the only preoperative medication (two cases) was a small amount of scopolamine.

The anesthetic agents used were cyclopropane for the first few minutes, followed by nitrous oxide and oxygen after endotracheal intubation. For muscle relaxation, succinylcholine was used throughout the operation until the bypass was completed. Advantage was taken of the hypothermia that developed during by-pass to maintain amnesic analgesia: Neither the blood nor the patient was warmed during the period of extracorporeal circulation, and when the procedure was completed the patient rewarmed spontaneously. During the by-pass stage a mixture of helium and oxygen in a ratio of 60:40 was used to gently inflate the lungs. After the by-pass, manual ventilation was resumed with oxygen or with a half and half mixture of nitrous oxide and oxygen.

Operation

In the early cases in the series, bilateral anterior thoracotomy through the fourth intercostal space was used. Later, median sternotomy was found to be more satisfactory in that respiratory distress was less with it and postoperative complications were fewer. Also the incision caused less pain and it had the added advantage that only one pleural space had to be entered. After the incision is made the pleural space is opened so that when the pericardial sac is opened it can drain into the space. This is done to avoid cardiac tamponade or collection of blood in the mediastinum. While one surgeon is opening the chest, others isolate the femoral vessels beneath Poupart's ligament. The patient is given 3 mg. of heparin per kilogram of body weight, and a catheter is inserted into the left femoral artery and on into the aorta for measuring pressures. A larger catheter is inserted into the right femoral artery to return blood from the heart-lung machine to the patient. A Rummel tourniquet is placed around the base of the right atrial appendage, and the tip of the appendage is incised. The atrial septum is palpated for any evidence of a defect. The superior and inferior vena cavae are then cannulated through the incision in the atrial appendage, the cardiopulmonary by-pass is put into operation and the necessary intracardiac procedures are performed. When it is completed, extracorporeal circulation is stopped, the cannulae are removed from the vessels and cavae and all the incisions are closed.

RESULTS OF OPERATIONS

Five patients with atrial septal defects were operated upon and complete repair of the defect was achieved in all of them. One patient died of subacute bacterial endocarditis four weeks after operation. The infecting organism was hemolytic staphylococcus aureus, coagulase positive. The source of infection was believed to be a Statham gauge which had been stored in benzalkonium chloride solution (Zephiran®) for sterilization. Thereafter a 10 per

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*The apparatus, which was constructed by Corco, Inc., 10418 Venice Building, Los Angeles 34, has already been completely described.[1]

cent formaldehyde solution was used for the purpose. The heart-lung machine is sterilized by autoclaving.

Two patients had pulmonary stenosis and atrial septal defects. The lesions were completely corrected and both patients survived and did well.

One patient had atrioventricularis communis. Both the mitral insufficiency and the atrial septal defect were corrected and the patient did well.

Twenty-three patients were operated upon for ventricular septal defects. Most of them had elevated pressure in the pulmonary artery and the right ventricle, with symptoms. In some cases the pressure was as high as 90 mm. of mercury in the right ventricle. Two patients in this group died, one of them 36 hours after operation owing to formation of a large clot of blood surrounding the entire heart, the pericardial sac having been intentionally closed loosely. Loose closure is no longer practiced but instead the pericardial sac is widely left open. The patient was the fourth one operated upon in the series. The other death occurred in the immediately postoperative period. The patient had been in congestive failure, which was thought to be the primary cause of death.

Three patients with ventricular septal defects and pulmonary hypertension were operated upon. In these patients the pressure in the pulmonary artery was equal to that in the aorta and there was a bidirectional shunt. Two of them died, one at the time of the operative procedure when the heart did not resume a good beat after closure of the defect, and the other of respiratory insufficiency 36 hours after operation. The remaining patient at last report was living and well, with the defect closed. It is our impression that the disease entity of pulmonary hypertension with bidirectional shunts is not the same as the usual ventricular septal defect. It is probably due to essential pulmonary hypertension, with ventricular septal defect a concomitant rather than a causative factor.

Operation for the correction of mitral stenosis and mitral insufficiency was done in two cases. One patient died, owing to an inadvertent tear in the common iliac artery during the threading of the catheter for perfusion into the aorta. This necessitated an extensive retroperitoneal dissection, and postoperatively the patient bled a great deal from the retroperitoneal area.

Eleven patients with the tetralogy of Fallot were operated upon. All had ventricular septal defect, overriding of the aorta, pulmonary stenosis and right ventricular hypertrophy. In eight of these patients the pulmonary stenosis was of the infundibular type. In three it was valvular. The defects were corrected in ten cases, the repair consisting of closure of the ventricular septal defect, correction of the overriding of the aorta and either pulmonary valvotomy or resection of the infundibular stenosis. One of the 11 patients died, nine were restored to a perfectly normal existence and one was still recovering from operation at the time of this report.

One patient, 47 years of age, had aortic valvotomy for repair of acquired aortic stenosis. The duration of cardiopulmonary by-pass was 45 minutes and the heart was completely stopped for a half hour. The patient recovered promptly and returned to work.

One patient, a 38-year-old woman, had a large mass in the left atrium owing to a sinus of Valsalva fistula rupturing into the left atrial wall where aneurysmal dilatation developed and then ruptured into the left atrium. During repair of this defect, extracorporeal circulation and oxygenation was maintained for an hour and ten minutes. The patient recovered promptly.

In the case of a 23-year-old woman with infundibular stenosis, the pressure in the right ventricle was 220 mm. of mercury. Operation with the Brock technique three years previously had been unsuccessful. With use of the heart-lung machine the lesion was resected. Thereafter the patient felt well.

ADDENDUM: The heart-lung machine has now been used in 120 cases and the results have been essentially the same as in the first 50.

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REFERENCE

1. Kay, J. H., and Anderson, R. M.: An autoclavable stationary screen pump-oxygenator with filmer, J. Thor. Surg., 36:463-469, Oct. 1958.